ALTERNATIVE ESTIMATES OF NET ECONOMIC BENEFITS FOR BILLFISH-TUNA RECREATIONAL-COMMERCIAL FISHERMEN IN KAILUA-KONA, HAWAII

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During 1976 about 1,500 trolling vessels were used primarily for weekend fishing trips in the Hawaiian Islands. About half of the weekend trolling fleet's total catch is tuna and a quarter is billfish. About 60% of the total catch is sold making the fleet one of the major suppliers of commercial fish in Hawaii.

An economic analysis of the weekend trolling fleet is prompted by the Fishery Conservation and Management Act of 1976 which extends Federal jurisdiction to 200 miles around the Hawaiian Islands. A typical question put by the public policymaker is what are the comparative effects on the nation's economic well-being of various possible management options. Billfish is one fishery in Hawaii to be managed.

Since participants of the weekend trolling fleet sell most of their catch and engage in fishing as a recreational activity they do not fit neatly into either economic role of consumer or producer. This dual role of the weekend fisherman has hampered the theoretical and empirical economic analysis for most fisheries with a fleet which cannot easily be divided into autonomous commercial and recreational components.

Measure of total net economic benefits. Net benefits are estimated for weekend fishermen using 386 vessels in Kailua-Kona during 1976. Net benefits are measured as the summation of consumer surplus and net revenue. Consumer surplus for the recreational-commercial fisherman is defined as the difference between what the individual is willing to pay for different quantitites of a good and what he actually pays. If the marginal utility of money is constant consumer surplus may be measured as the area between the demand curve and the price line.[1]

Net revenue is based on revenue from the sale of fish and the cost of the fishing trips attributed to the fisherman's choice to make some commercial sales.

Specification of the recreational-commercial demand model. The demand model is estimated as an exponential function in the form

$$\text{(1)} \qquad \ln T_i = \beta_0 + \beta_1 P_i + \beta_2 V_i + \beta_3 C_i + \beta_4 Y_i + \varepsilon_i$$

where

T_i number of annual passenger trips for the ith vessel during 1976

P_i operating (average variable) cost per passenger trip for the ith vessel

V_i current value of the ith vessel and gear

C_i kilograms of fish caught per passenger trip for the ith vessel

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[1]For more details on consumer surplus see A. Marshall, Principles of Economics, 9th edition, The MacMillan Company, New York, 1961; J. M. Hicks, "The Four Consumer's Surpluses," Review of Economic Studies, vol. 12, 1944; and, A. M. Henderson, "Consumer's Surplus and the Compensating Variation," Review of Economic Studies, vol. 8, 1941.

Y_i annual income for the owner of the ith vessel

ε_i disturbance term

Leisure time is an important explanatory variable for recreational demand that is not specified in the model due to the absence of data. However, since most of the fishermen have full-time jobs the sample is likely to be relatively homogeneous with respect to leisure time. Other variables are included as the model is further developed.

Estimation of the models and alternative measures of net benefits. Preliminary estimates of the initial model revealed heteroscedastic problems in the survey data. Therefore a generalized least squares estimating procedure is used to estimate the models. Table 1 gives the results of five models in the untransformed versions.

Model I follows from the original specifications described above which treats the weekend trolling fleet as strict recreationalists. Evaluating the estimated equation at the mean values for all the independent variables except P yields the demand function

$$T = e^{4.308 - 0.017P} \tag{2}$$

It is assumed that the average vessel is used for at least one trip per year. Therefore, for levels of passenger trip demand less than the average number of passengers per trip, 2.56, demand is assumed to be perfectly elastic. Solving for P defines the upper bound of the

Table 1.--Regression coefficients, t-statistics, F-tests, and goodness-of-fit measures in regression equations to explain the natural logarithm of passenger trips taken by a vessel (LT) in Kailua-Kona, Hawaii during 1976 using cross-sectional observations.**

Model	No. of observations (n)	Independent variable											
		CONSTANT	P	V	C	$Y^{\hat{\delta}/2}$**	D_1	D_2	D_3	PD_3	I	R^2***	F
I	114	4.27 *	-.02 *	.27E-4 *	.004	-2.02						.50	26.94
		(8.75)	(-2.60)	(2.44)	(.47)	(-.31)							
II	114	3.87 *	-.02 *	.30E-4 *	-.02	-1.01	.26	.81 *				.62	29.12
		(8.95)	(-2.84)	(3.09)	(-1.94)	(-.18)	(.79)	(5.86)					
III	49	3.96 *	-.02 *	.24E-4 *	.001	-12.90			.25			.79	32.12
		(10.87)	(-2.92)	(2.36)	(.06)	(-.32)			(.73)				
IV	114	3.91 *	-.02 *	.32E-4 *	-.007	-.67			.61*	.0009		.61	28.45
		(9.00)	(-2.70)	(3.20)	(-1.76)	(-.11)			(3.26)	(1.15)			
V	114	4.14 *	-.02 *	.29E-4 *	-.004	-3.54					.47 *	.60	32.66
		(9.49)	(-2.93)	(2.89)	-1.07)	(-.61)					(5.33)		

Number of observations	Estimated heteroscedastic parameter $(\hat{\delta})$**and t-statistic
114	-.56
	(-1.59)
49	-1.00
	(-1.88)

* coefficient is significantly different from zero at the 95% level (two-tail test)

**The regression results are on the transformed model for a weighted least squares regression using $\hat{Y}_i^{\delta/2}$, $i = 1,\ldots, n$, as the weights obtained by regressing $(\hat{LT}_i - LT_i)^2$, from an ordinary least squares regression, against $Y_i^{\delta}e^{\rho}$ where ρ is a homoscedastic error term for the regression equation in logarithmic form. Using the independent variables other than Y to estimate the error variances results in heteroscedastic parameters which are not significantly different from zero at the 90% level.

***Not corrected for generalized least squares estimation procedures.

price range. Average variable cost defines the lower bound of the price range when measuring consumer surplus. Evaluating the integral of Eq. (2) for the interval P = [11.40, 198.52], the measure of consumer surplus for an average vessel is $3,554. Since costs are considered in the measure of consumer surplus, the gross revenue from the sale of fish is considered as additional net benefits amounting to $688 per year for an average vessel. Total net benefits for a vessel using this method, then, amount to $4,242, or $1,637,412 for the fleet of 386 vessels in Kailua-Kona during 1976.

This approach ignores the fact that at least some of the trips were prompted by the fleet's ability to sell some of its catch. But from Model I it is not possible to discern the number of additional trips. It is likely, though, that the above estimate for the fleet is an overestimate due to the resulting double counting. On the surface, however, the measure seems intuitively appealing from an economic standpoint since the total measure is close to determining a larger consumer surplus after reducing the price by the average revenue generated per passenger trip.

Model III is one possible approach of improving on the first measure of net benefits by dividing the fleet into individual recreational and commercial components. In this model only vessels selling less than 17% of their catch are analyzed based on the results of Model II where

D_1 equals 1 if the weight sold is less than or equal to 17% of total weight caught; equals zero otherwise

D_2 equals 1 if the weight sold is greater than 17% of total weight caught; equals zero otherwise

D_3 equals 1 if any of the catch is sold; equals zero otherwise

The results of Model II indicate that for the component of fishermen who sell their catch, those selling 17% or less do not behave significantly different than the component selling no fish at all. But those selling more than 17% of their total catch appear to take more trips which may be attributed to their ability to sell the catch which is in excess of the fish they demand for home consumption or gifts.

Assuming, then, that the fleet may be divided into recreational and commercial components, the following demand function may be derived from Model III to estimate the consumer surplus for the recreational component of the fleet.

$$T = e^{4.016 - 0.025P} \quad (3)$$

The demand function for an average vessel is representative for about 166 vessels in Kailua-Kona during 1976. Evaluating the integral of Eq. (3) for the interval P = [10.94, 124.95], the estimated consumer surplus is $1,620, which yields $268,920 for the 166 vessels.

The other 220 vessels in the fleet are treated strictly as commercial vessels which show a negative total net revenue of -$1,415. The combined measure of net benefits for the recreation and commercial components of the fleet total $267,505.

This second alternative measure of net benefits for the total fleet appears to be low since it is unlikely that the entrepreneurs of the commercial component would remain in the fishery with returns close to zero. Furthermore, even though the intercept dummy variable, D_2 in Model II, indicates a difference in the groups attributed to the ability to sell an excess catch, there is another important behavioral variable which indicates the two groups are not so different. Model IV introduces a new variable, PD_3, the product of P and D_3 which assumes that the commercial component responds differently to changes in average variable cost than the component which does not sell its catch. The results of estimating Model IV using the slope dummy variable indicate that the respective coefficient is not significantly different from zero. Under usual conditions a firm's output is inversely related to costs, but it is not clear that this is an appropriate interpretation for a weekend fishery with participants who have other full-time occupations. The fact that the demand slopes of the two proposed components of the fleet are not significantly different creates more serious questions about treating the components as mutually exclusive in the analysis. The fact that the commercial component just breaks even suggests that there are benefits not being measured and that this second alternative measure underestimates net benefits for the total fleet.

Model V, then, treats the fleet as a single group with some fishermen selling a part of their catch. In the previous models, the average fisherman will continue to take more trips during a given year until the value of the last trip is equal to the cost of the same trip. That is the recreational fisherman will continue fishing until the marginal value is equal to the price of fishing. The fisherman will take additional trips only if he can accrue benefits in addition to the existing recreational benefits. The fact that fishermen can sell part of their catch in Kailua-Kona prompts many to take additional trips. These decisions may be reflected in the length of a day's trip, number of trips per week, month, or year. But additional trips for an average vessel which are prompted by commercial sales should be attributed to commercial motivations--not measured as additional recreational benefits as in the first alternative measure of net benefits. And also, the recreational benefits which accrue to fishermen should not be deleted just because a part of the catch is sold as in the second alternative measure of net benefits.

The commercial motivation edging the weekend recreational fisherman can be measured by a number of variables. One variable is certainly the price of fish. The price of fresh fish in Hawaii is relatively volatile due to large fluctuations in seasonal consumer demand. It is likely that a ~~recreational~~-commercial fisherman will respond differently to a fish price change based on the proportion of total catch sold. A relative index is desirable since the quantity of fish usable for home consumption and donations may vary widely for different fishermen. Therefore the variable I is introduced which is an index of relative excess landings for consumption and donations weighted by the average value of sales for the year. The demand curve estimated from Model V is

$$T = e^{4.316 - 0.017P} \tag{4}$$

The average elasticity of demand with respect to I is 0.40. For those fishermen who sell none of their catch, a change in the ex-vessel price of fish will not influence the number of trips they take. But for those fishermen who do sell some of their catch, the larger the excess catch, the more sensitive will be the change in demand due to a change in fish prices. Setting I equal to zero, then, shifts the demand curve such that

$$T = e^{3.975 - 0.017P} \tag{5}$$

Evaluating the integral of Eq. (5) for the interval P = [11.40, 177.27] yields $2,410 for the vessel and $930,260 for the fleet in recreational consumer surplus. Net revenue received for the additional trips prompted by commercial incentives amounts to $187,210, yielding a total net benefit for the fleet of $1,117,470.

This third alternative measure of net benefits is less than the first measure, $1,637,412, which considered all members of the fleet recreationalists, and it is greater than the second measure, $267,505, which divided the fleet into autonomous recreational and commercial components.

Possible areas of application for public policy issues. The results of the final model indicate that recreational demand is insensitive to incremental changes in the catch rate. That is the estimated coefficient for the variable C is not significantly different from zero. For the fleet analyzed here the only change in net benefits, attributed to a policy which may change the catch rate, will be due to changes in net revenue from the sale of fish.

Policy alternatives which include overall quotas, quota allocations to various user groups, limited fishing days per year, or bag limits may be analyzed by estimating net benefits by passenger-day trip or by quantity of fish based on the results of the analysis.